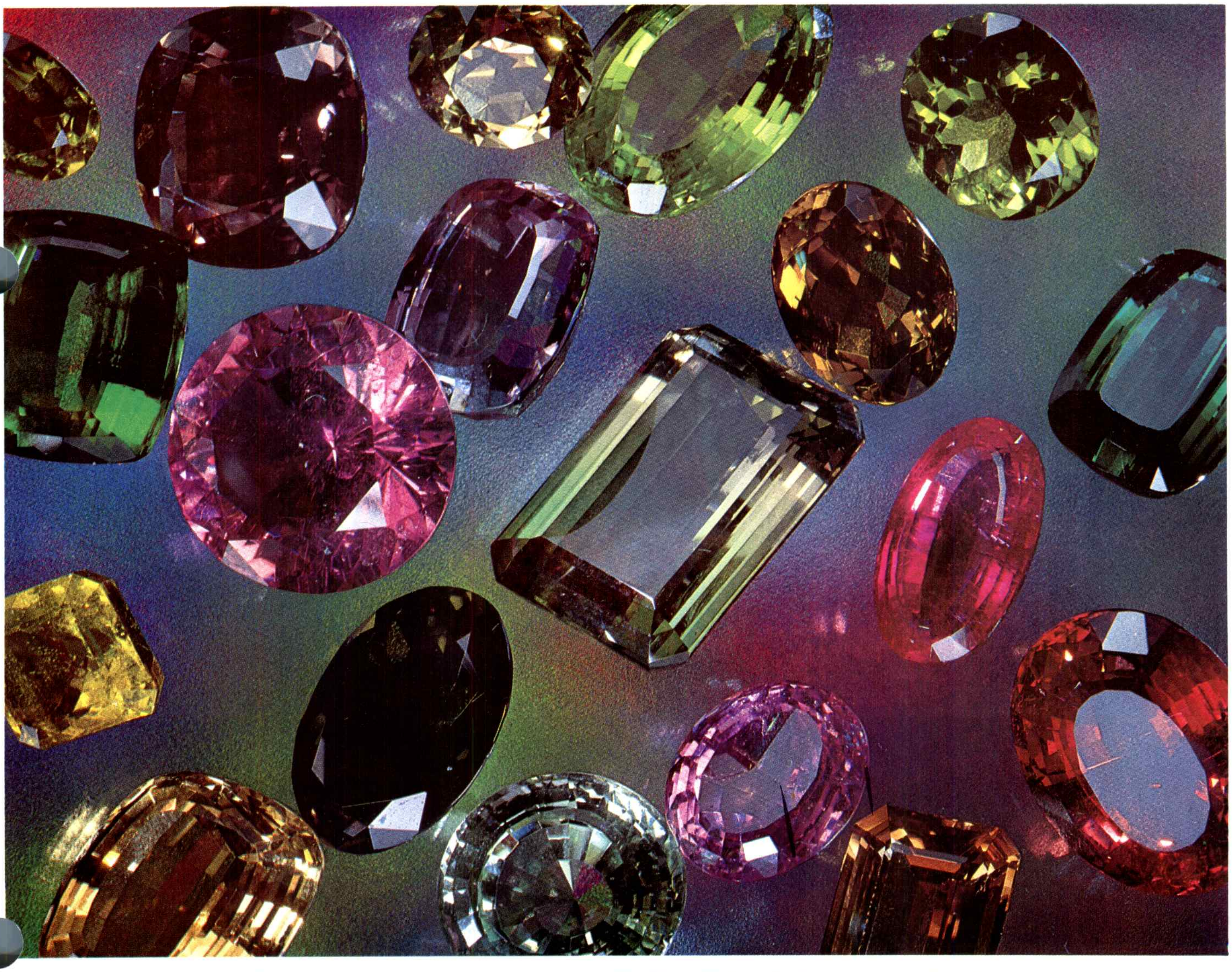
COLORED STONES

ASSIGNMENT 9

CAUSES AND JUDGMENT OF QUALITY IN STARS, CAT'S-EYES ETC.

IDENTIFICATION, PRODUCTION, MARKETING, BUYING



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I. INTRODUCTION.

Of special interest in the study of gemology is the subject of phenomena. Briefly, as applied here, it is described as those unusual optical effects displayed by some gem varieties. The interesting crossed lines of reflected light seen in star sapphires and star rubies, the billowy bluish sheen displayed by moonstone, and the vivid multiple flashes of color observed in fine opals are all examples of phenomena. These and other unusual effects will be studied in this assignment.

The phenomenal effects observed in gems may be classified under one of three main types: (1) reflection of light from inclusions, (2) selective absorption of light, and (3) interference of light.

II. PHENOMENA RESULTING FROM REFLECTION OF LIGHT.

A. Chatoyancy (pronounced shah-TOY-an-see).

Chatoyancy is the property of a gemstone to reflect light in a line resembling the contracted pupil of a cat's eye. In a fine cat's-eye it appears as a narrow, well-defined light-colored streak across the summit of the stone that moves as the stone is turned. Cat's-eye is a variety of the gem species chrysoberyl. When chrysoberyl exhibits a movable light that is not confined to a narrow band, it is usually called CYMOPHANE (pronounced CY-mo-fane), although the term is sometimes applied to chrysoberyl that exhibits a movable light effect of any kind.

Fine cat's-eye contains a vast number of minute, parallel needlelike inclusions that may be cavities or, more often, included fibrous crystals. The light-colored streak, which is always at right angles to the fibers, is produced by reflections from these inclusions (Figure 1). A high or medium-high cabochon results in the most desirable "eye," since this form of cutting limits the reflections that are visible from any one direction to a sharp band of light. In a flat-topped stone, reflections are seen from the entire surface (sheen). In a cabochon cut, the light reflected from the inclusions is refracted out at different angles; thus only a narrow band of light is seen from any one direction (Figure 2).

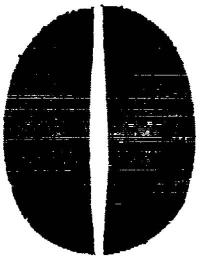

FIGURE 1.

A form of chatoyancy may be observed by holding a spool of glossy thread under a single light source. A narrow chatoyant band will be visible on the apex of the spool at right angles to the threads. The round form of the spool serves the same function as the cabochon cut of a chatoyant gem.

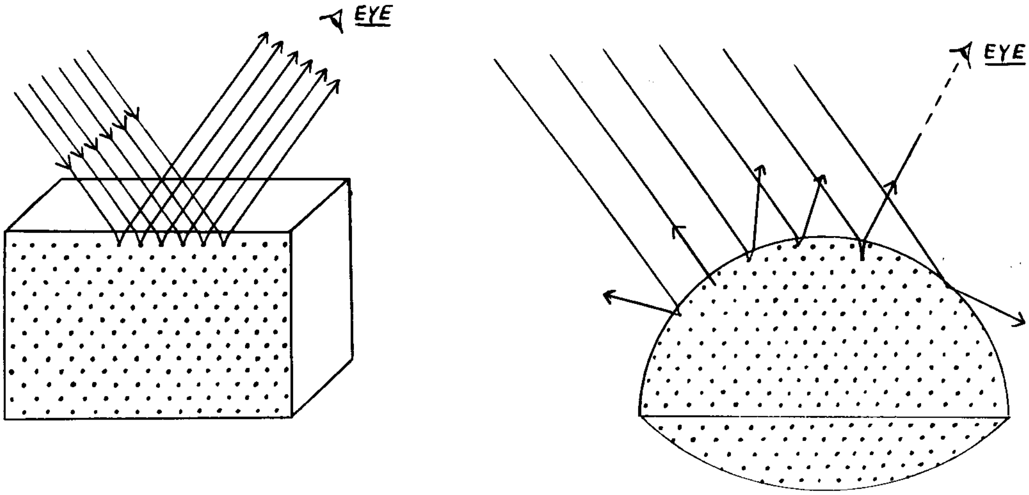

FIGURE 2.

Tiger's-eye, a variety of quartz often incorrectly called "crocidolite," is usually a yellow-brown stone with a wavy fibrous structure. The appearance is similar to a series of broad cat's-eye effects. It may be dyed any number of colors. Tiger's-eye was formed when crocidolite, or blue asbestos, a fibrous mineral, was replaced by quartz but whose fibrous structure was preserved. In other words, the quartz is a pseudomorph after crocidolite. When cut en cabochon, a cat's-eye effect is produced by reflection from these fibers. The blue variety, which probably contains unaltered crocidolite, is sometimes called hawk's-eye. There is also a fine cat's-eye variety of quartz that resembles its more valuable counterpart, chrysoberyl cat's-eye. This type has much finer inclusions than tiger's-eye, but lacks the silky transparency of chrysoberyl. There are a number of other gemstones in which cat's-eye varieties are more or less uncommon. These include tourmaline, beryl, feldspar and a few infrequently encountered gemstones such as scapolite, diopside and enstatite.

Judgement of quality of a cat's-eye is based on color, the position of the eye (it should be straight and thin and follow the crest of the cabochon exactly when the light source is directly over the stone), transparency, and the shape of the stone. The stone should not be heavy below the girdle; it should have a sufficiently sharp girdle to permit the prongs to hold it firmly; it should have a symmetrical outline; and its cabochon surface should not be too high nor too sharply domed. The eye should follow the long diameter of the stone.

B. Asterism.

Stones cut en cabochon that reflect light in the form of intersecting bands of light are known as ASTERIAS. The words ASTERIA, ASTERIATED AND ASTERISM are derived from the Greek word ASTER, meaning STAR. The star may be four, six or even twelve rayed. Three- , five- and ten-rayed stars are also known, but these are "freak" gems in which one ray of the star is missing due to the absence of essential inclusions in one area of the stone. Although stars are most commonly seen in ruby and sapphire, other gems that occasionally display asterism are almandite garnet, spinel, beryl, rose quartz and chrysoberyl.

In general, asterism is caused by reflection of light from minute, oriented needlelike crystals. When the stone is cut en cabochon, the reflected light is visible as bright intersecting lines. In star stones of the corundum species, which crystallize in the hexagonal system, numerous tiny elongated crystals are distributed in planes perpendicular to the principal vertical crystal axis and oriented in directions parallel to the faces of the hexagonal (six-sided) prism (Figure 3). The star-producing inclusions in synthetic star ruby and sapphire are arranged in the same pattern as in the natural.

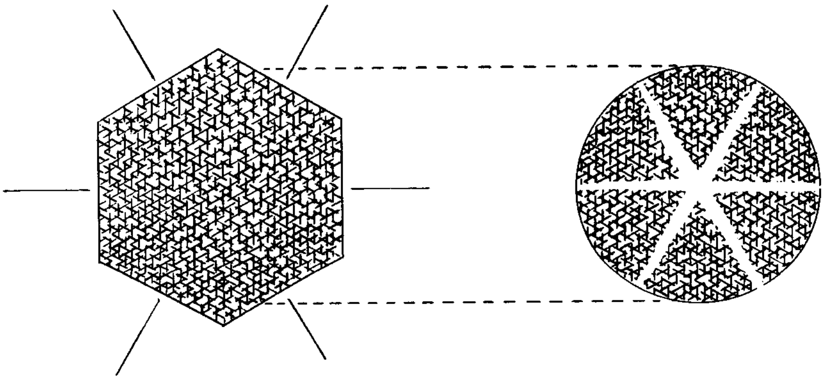

FIGURE 3.

It will be noted in Figure 3 that these minute crystals are oriented in three directions and intersect at 60°; through reflection, they produce three chatoyant bands at right angles to the inclusions, thus forming a six-rayed star. When observing a cross section of a crystal of this nature, one can see a surface sheen, which is the result of light being reflected from these oriented crystals within the stone. It is partly on this basis that one can determine whether a crystal can be fashioned into a star stone. This surface sheen can be resolved into a star by the use of the cabochon cut. The girdle must be placed exactly parallel to the plane in which the needles lie, in order for the star to be centered at the apex of the cabochon.

The minute needlelike inclusions that are essential to fine stars are called SILK, because of the silky sheen they impart to the stone. Needles coarse enough to be visible individually under 10x or 30x are too large for sharp star production. Just as the large fibers in most specimens of tiger's-eye produce only a wide chatoyant band, coarse needles in any other gem mineral likewise produce an indistinct star. The sharpness and perfection of the star in first-grade Linde synthetic star sapphires and rubies is the result of the even distribution and tiny size of the needles, or silk. Since synthetic stars contain needlelike inclusions that are only clearly visible under 100x or higher magnification, the presence of coarse needles may still be considered proof of genuine origin in corundum.

C. Aventurescence (pronounced ah-ven-chur-ESS-ence).

Aventurescence is the name applied to a display of bright or strongly colored reflections from a translucent mineral. It is seen in sunstone (a variety of oligoclase feldspar) and in aventurine quartz (a spangled green variety of massive quartz). In feldspar it is caused by reddish, metallic reflections from minute, flaky inclusions of a variety of hematite arranged parallel to planes of repeated twinning. Fine sunstone resembles moonstone, but with a golden instead of a bluish reflection. In quartz it consists of fairly vivid reflections from green inclusions in a white background, or shiny reflections from included flakes of mica in a green background.

III. PHENOMENA RESULTING FROM SELECTIVE ABSORPTION.

Although selective absorption is the basic cause of the body color of any gem, on rare occasions the type and degree of absorption leaves the specimen sensitive to the slight differences between incandescent light and daylight radiation. Artificial incandescent light contains a predominance of red wavelengths, whereas daylight contains a predominance of blue and green wavelengths. The result is a difference in the color of the stone, depending on the type of light to which it is exposed. This phenomenon is called CHANGE OF COLOR, and the most notable example of a stone displaying it is alexandrite, a variety of chrysoberyl.

At first it might seem that the difference between daylight and artificial light would cause any stone to display a change of color when viewed under two sources alternately. However, in order for this to be obvious, the stone must be capable of absorbing a considerable portion of most of the wavelengths of light emitted by the light source, but a portion of the predominant wavelengths must be transmitted readily. Thus the alexandrite appears red in incandescent light, since it is transmitted with little absorption and the long wavelengths predominate in incandescent light. In daylight, on the other hand, shorter wavelengths predominate, and since green is transmitted readily by the alexandrite while other short wavelengths are absorbed, the stone appears green. The more closely the stone approaches a pure green and a pure red, the better the quality.

A change of color occurs in other than natural chrysoberyl. Synthetic alexandrite is presently manufactured by Creative Crystals, Inc., in California, and by the Kyoto Ceramics Corporation in Japan. Both of these synthetic alexandrites have a distinct change of color. A change of color similar to that in natural alexandrite is also noted in the rather rare alexandrite-like synthetic spinel. An alexandrite-like synthetic corundum, which has often been incorrectly referred to as "synthetic alexandrite," changes from a gray bluish green in daylight, usually with purplish overtones, to a color similar to amethyst under artificial light. Occasionally, a natural sapphire, and more rarely a variety of beryl, spinel or tourmaline, will show some change from one light source to another.

IV. PHENOMENA RESULTING FROM INTERFERENCE OF LIGHT.

If two rays of identical light are superimposed so that they travel in exactly the same path, two things may occur: (1) If they are in phase, they will ASSIST each other; (2) if they are out of phase, they will tend to CANCEL each other. In the latter case, if they are exactly out of phase, the wave motion will be entirely cancelled, resulting in DARKNESS. When they assist each other, the result is INCREASED INTENSITY. If rays of WHITE

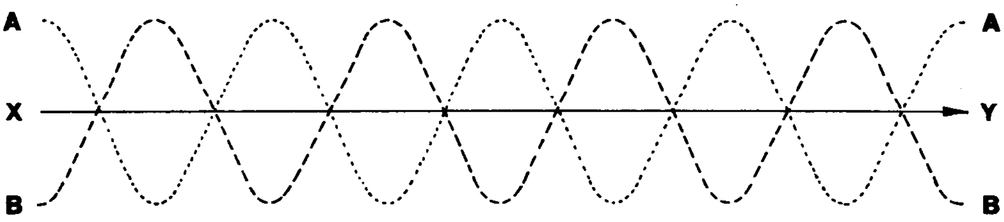

Fig. 4

light overlap, the resultant interference may produce spectral colors. In other words, waves of certain of the hues that comprise white light may cancel each other, leaving only waves of certain other hues.

In Figure 4 two waves (A and B) of the same length traveling the path XY at the same time, but so timed that A is on the upward swing when B is on the downward motion, result in the two cancelling each other. In effect, A and B, which are equal in length, are subtracted from one another.

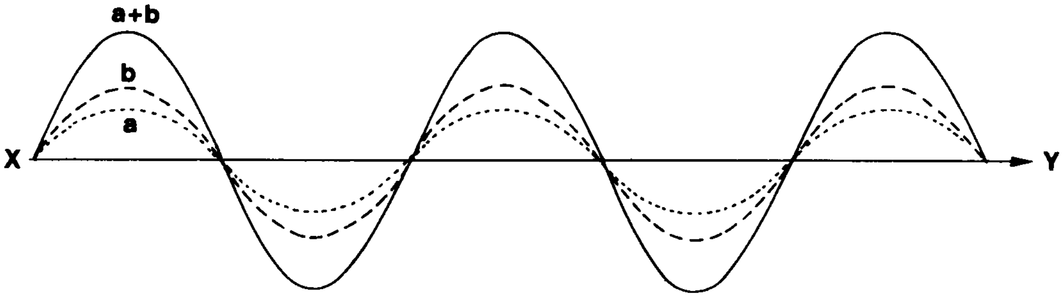

Fig 5

When the two waves are superimposed on one another so that each is moving from X to Y "in step" (as in Figure 5), the result is intensification: A is added to B. If two waves are between the two extremes shown in Figures 4 and 5, the results vary from some cancellation to some intensification of the light, depending on whether the relationship of A and B is closer to that illustrated in Figure 4 or that in Figure 5.

There are only a few situations in nature in which the necessary conditions for interference occur, for the basic condition of two or more beams traveling the same path at the same time is an unusual occurence.

Figure 6 illustrates how interference is produced. A ray of light is directed at an extremely thin transparent film such as oil on water. To simplify the illustration, we will consider only two portions of the ray, labeled A and B. As these rays strike the film, a portion of the light is reflected; the remainder is refracted into the film, reflected from the bottom surface, and refracted back into the air, following the same path as the light reflected from the surface. This point at which the reflected and refracted rays coincide and begin to travel the same path is encircled in the sketch.

Thus for a certain thickness of the layer, or film, as well as for different angles of incidence for the light, the red waves might amplify one

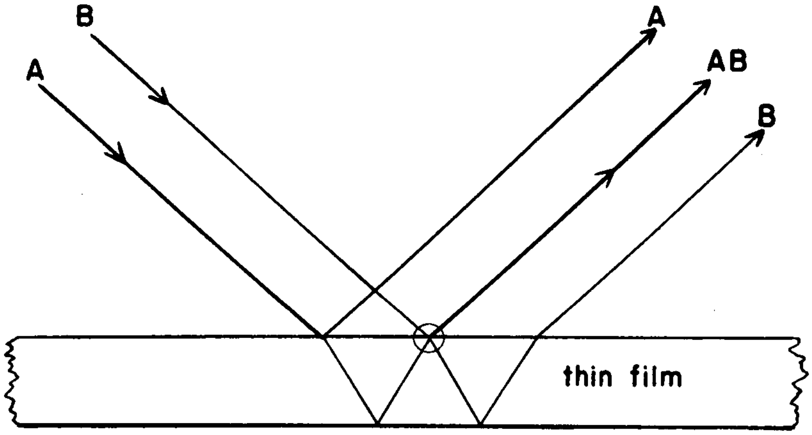

FIGURE 6.

another to produce an intense red light, whereas some of the other waves are cancelled; or the red rays may cancel one another and the blue rays be intensified. The colors thus produced are known as INTERFERENCE COLORS. The brilliant colors of soap bubbles and the colors produced by cracks in topaz, rock crystal, glass, etc., are due to this interference. Whenever there are such thin, transparent films or layers of different material, this interference of light occurs, with its resulting colors.

A. Play of Color.

This is the name applied to the multiple colors displayed by fine opals. These colors form a patchwork, with the color of each patch changing as the stone is turned. A predominance of red flashes is most desirable, with green next, and blue less desirable.

Play of color is caused by diffraction of light and variations in refractive index from innumerable, regularly arranged, optically transparent spherical particles of amorphous silica and from the spaces, or voids, between these particles. The spheres, and hence the voids, are arranged regularly in three dimensions (face-centered cubic), so that the whole arrangement makes a three-dimensional diffraction grating. The important feature is that the spacing of the voids is the same as that of the spheres, and when this is about that of the wavelength of visible light, diffraction occurs. The angle through which the light is diffracted varies continuously with wavelength, so that different colors appear at different angles, thus producing play of color. Only pure spectral colors can arise from this process. This theory of the internal structure of precious opal was proved in the mid-1960's by research with the electron microscope.

The play of color associated with fine opal is sometimes referred to as "opalescence," but this term more correctly refers to an internal milky or pearly appearance. Because of its double usage, the word is avoided in American gemology. Play of color should not be confused with "fire," which is another name for dispersion, as observed in transparent faceted stones.

B. Labradorescence (pronounced lab-rah-door-ESS-ence).

Labradorite, a species of the feldspar group, is usually a somewhat dull-gray stone in the rough. When it is polished, large patches of a vivid solid hue often appear that change gradually as the stone is moved. They do NOT appear in flashes as in the opal. This effect is sometimes called CHANGE OF COLOR, as distinguished from the play of color in opal. However, as mentioned previously, change of color is also used to describe the phenomenon seen in alexandrite, an entirely different effect.

Labradorite is repeatedly twinned and is made up of a large number of very thin plates. These thin plates set up the condition necessary for light interference, as described in the foregoing paragraphs. In addition to this effect, it is probable that a distribution of tiny areas of feldspar of a different composition cause a diffusion, or scattering, of light that is superimposed on the interference caused by the thin plates.

C. Iridescence (pronounced ear-ih-DESS-ence).

Iridescence is a display of prismatic colors produced by light interference from very narrow fissures enclosing thin films of air or liquid. Such a condition is given a name in quartz (iris quartz or iris agate), but it may be encountered in any gemstone that has been fractured or in which a cleavage has started to develop.

D. Orient.

This is the prismatic sheen on which the beauty of the pearl mainly depends. Interference and diffraction of light on the tiny overlapping plates on the surface of the pearl produces this effect. Diffraction produces the multiple colors sometimes seen on the jagged edges of broken glass. It is a phenomenon distinct from both dispersion and play of color.

E. Adularescence (pronounced ad-u-lar-ESS-ence).

Adularescence, or moonstone effect, often confusingly called "opalescence" or "schiller," is the name given to feldspar (usually orthoclase) that exhibits a blue to white sheen in certain directions. When the stone is cut en cabochon, a floating, billowy, bluish or white light is noticed as the stone is turned.

This moonstone effect, which is visible only in certain directions in the feldspar crystal, seems to be caused by somewhat diffused reflection of light from repeated-twinning planes or parallel intergrowths of another feldspar of a slightly different R.I. from the main mass of orthoclase.

F. Girasol Effects (pronounced JIR-ah-sol).

The adjective girasol is applied to the varieties of several species of minerals, including opal, corundum, chrysoberyl and quartz, that exhibit a movable or billowy light effect as the stone is turned. The effect is often mistaken for adularescence, but, although somewhat similar, the appearance is more cloudy. As a noun, girasol refers only to the variety of opal that produces this effect, but it is used as an adjective in such terms as girasol sapphire and girasol quartz.

V. DISTINGUISHING PHENOMENAL STONES.

One point relating to the identification of gemstones that is emphasized in the GIA courses is the danger of making identifications by sight alone. However, those gemstones that exhibit some of the unusual reactions on light described in this assignment are sometimes so distinctive in appearance as to permit sight identification.

For example, the play of color seen in opal is not duplicated in any other gemstone nor effectively in any imitation; the only effective substitute is a doublet made from a thin piece of fine-quality opal cemented to a supporting piece such as chalcedony.

Labradorite, a stone that finds little use as a gemstone, displays a change of color that is seldom confused with that of opal, since, unlike the usual tiny mosaic of different colors in opal, the colored light is reflected from thin plates of UNIFORM thickness and the color is confined to ONE hue over large areas.

The only important substitutes for natural phenomenal stones are milky-white chalcedony, often sold as "moonstone"; asteriated rose quartz with a colored-foil backing; synthetic corundum or spinel with fine lines engraved on the flat back of the cabochon and backed by metal foil to create a star effect; synthetic star sapphires and rubies; and the poor glass imitations of opals, stars and cat's-eyes.

In general, these substitutes are detected readily by their lack of resemblance to the natural stones they represent. Opal doublets, unless mounted in a gypsy-type mounting, are detected easily by the obvious separation between the thin pieces of natural opal and the rough backing material.

Foilbacks used to imitate star sapphire and ruby were once limited to rose quartz that displayed a weak star without foil backing. Red and blue foil imparts a deep ruby and sapphire color only when star-quartz foilbacks are viewed from above. Looking through the cabochon from side to side, they are nearly colorless.

Synthetic corundum and spinel with fine lines engraved on the back in a three-sided pattern from which reflections to the top of the cabochon produce a star may be detected easily by inspection for the obvious line of demarcation between the top and back portions.

Synthetic star material made by Linde Air Products Co. is much more difficult to detect. To the eye, the color of these synthetic stars is so near the finest quality natural stone and the stars so perfect that the observer becomes suspicious that they are "too good to be true." However, for positive identification, the usual tests for synthetic corundum must be made. These tests will be described later in the course.

The milky chalcedony and other types of milky quartz that are often sold unethically as "moonstone" lack the floating, billowy, bluish or white light and the transparency of fine moonstone of the feldspar family. Some glass imitations of opal appear to be made by placing metal foil over a bead of glass near the melting point, then superimposing a second globule of glass with sufficient force to deform the foil so that it gives an impression vaguely akin to that of opal.

VI. EXPLOITING PHENOMENAL STONES.

It is interesting that many jewelers who say that "colored stones don't sell" are likely to include in their stocks opals, star sapphires and cat's-eyes, because they have a certain amount of appreciation for these phenomenal stones and this appreciation enables them to sell such stones. Perhaps the reason for this is the tangibility of the unusual optical effects shown by these stones. The fact that no two fine opals, cat's-eyes, stars, alexandrites or other phenomenal gemstones are exactly alike, plus the unusual appearance that each displays, may be used most effectively by the jeweler who is appreciative of this distinctive beauty. In each man there seems to be opposing tendencies: on the one hand, not to be considered "different"; on the other, to be better in at least one respect than anyone else. The effective retailer of colored stones takes advantage of the latter tendency by appealing to the desire to own finer and more unusual things than anyone else. This is a simple matter with phenomenal stones, each one of which may be presented to the prospective buyer as a stone that cannot be duplicated exactly. The most effective salesman of phenomenal gemstones that we have encountered surprised us with the statement that he could not sell diamonds. His deep appreciation for the unusual qualities represented by phenomenal stones made him so uniquely effective in their presentation to customers that, by comparison, his sales of diamonds were low.

If you wish to be an accomplished salesman of phenomenal stones, take every opportunity to study their rare beauty. Visit every gem collection that you can; there are notable ones in New York City, Chicago, Newark, Washington and other large cities. Examine carefully the magnificent phenomenal gems not only in such collections, but in those that appear from time to time in traveler's stocks, jewelry-store windows, and elsewhere.

The recent growing popularity of star sapphires and the increased sales of natural star sapphires after the synthetic's introduction illustrates what can be accomplished if even a small amount of effort is put into familiarizing the public with phenomenal stones. The basis of effective selling is knowledge and appreciation. Knowledge of phenomenal stones builds your appreciation of them.

ALL-INCLUSIVE TABLE OF PHENOMENA

Phenomena	Cause	Usual Style of Fashioning	Species and Varieties in Which Phenomena Occur
Iridescence	Interference of light from thin films of gas or liquid.	Cabochon.	Iris quartz, iris agate.
Play of Color	(1) Interference of light from layers of opal of different R. I. (2) Diffraction of light and variations in R. I.	Flat cabochons.	Opal.
Labradorescence	Interference of light from very thin plates, plus some diffusion.	Flat, carved, or flat cabochon.	Labradorite feldspar.
Adularescence	Diffusion of light from minute concentrations of another feldspar of slightly different R. I. from the main mass.	High cabochons, beads, spheres, carvings.	Albite feldspar, oligoclase feldspar, orthoclase feldspar.
Aventurescence	Reflection of light from inclusions of tiny platelets or flakes of another mineral.	Cabochon.	Albite feldspar, oligoclase feldspar, aventurine quartz.
Chatoyancy	Reflection of light from minute, parallel, needlelike inclusions.	High cabochon.	Chrysoberyl cat's-eye, quartz cat's-eye, tiger eye quartz, tourmaline cat's-eye, beryl, sapphire, ruby, scapolite, diopside, feldspar, enstatite.
Change of Color (Alexandrite Effect)	Selective absorption and selective transmission of light.	Any faceted or cabochon form.	Chrysoberyl (alexandrite), sapphire, syn. sapphire, syn. spinel, tourmaline.
Asterism	Reflection of light from sets of minute, oriented, needlelike inclusions.	High, medium or hollow cabochon.	Ruby, sapphire, syn. sapphire, syn. ruby, almandite garnet, zircon (green), rose quartz, aquamarine.
Orient	Interference and diffraction of light in the scalelike structure of the pearl.	Shapes of pearls as found in nature.	Pearl.
Girasol Effects	Varies with different species: diffusion, interference, or reflection and/or scattering of light by inclusions or impurities.	Usually cabochon but may be faceted.	Opal, corundum, quartz, chrysoberyl, etc.